Indirect and Semi-Direct Aerosol Campaign

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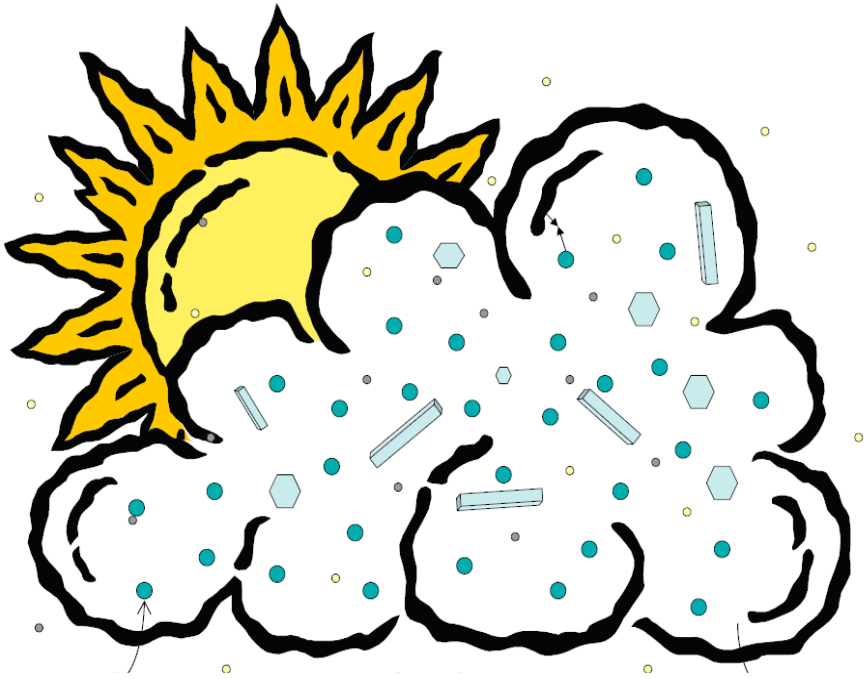


Barrow, Alaska

April 2008

ARM

SP

ISDAC Motivation

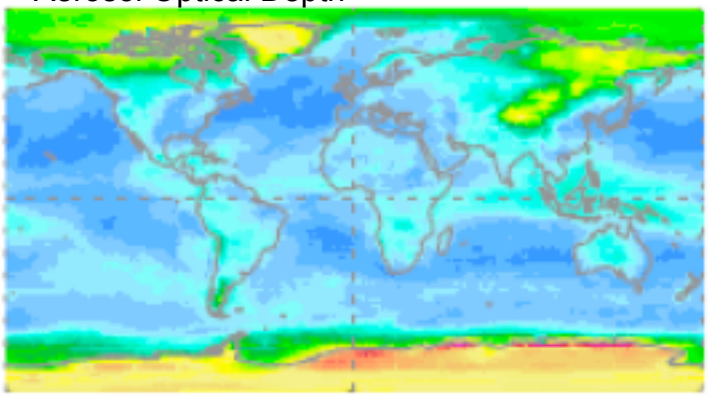
- Most studies of cloud-aerosol interactions have focused on warm clouds.
- Cloud-aerosol interactions are much more complex for ice or mixed-phase clouds than for warm clouds.
- The Mixed-Phase Arctic Cloud Experiment at the ARM site at Barrow in October 2004 has provided new insight into these interactions.
- The arctic air during April is expected to be much more polluted than the air during M-PACE.
- This contrast provides an opportunity to
  - distinguish between aerosol effects on arctic clouds under clean and polluted conditions
  - improve understanding of the scavenging of arctic aerosol during spring
  - identify the chemical signature of ice nuclei in the arctic

Why Study Scavenging in the Arctic?

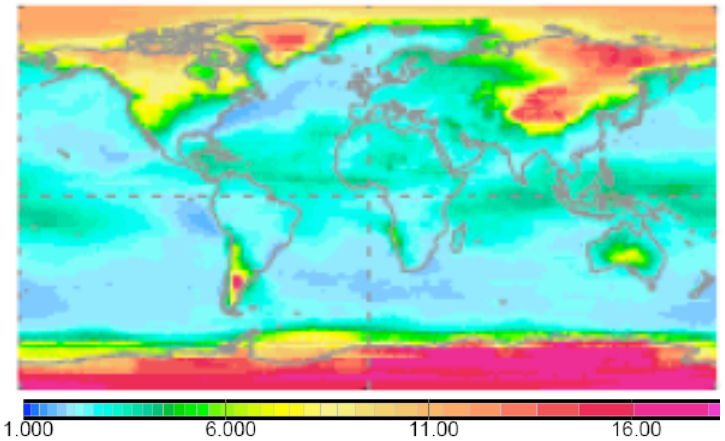
- Most of the relative uncertainty in simulated aerosol optical depth and mass loading is in polar regions.
- Most arctic aerosol comes from midlatitude sources.
- The treatment of transport is unlikely to cause a 10-fold uncertainty.
- Such uncertainty is probably due to the treatment of scavenging by clouds.

Max/Min of Central 2/3 of !6 Models

Aerosol Optical Depth



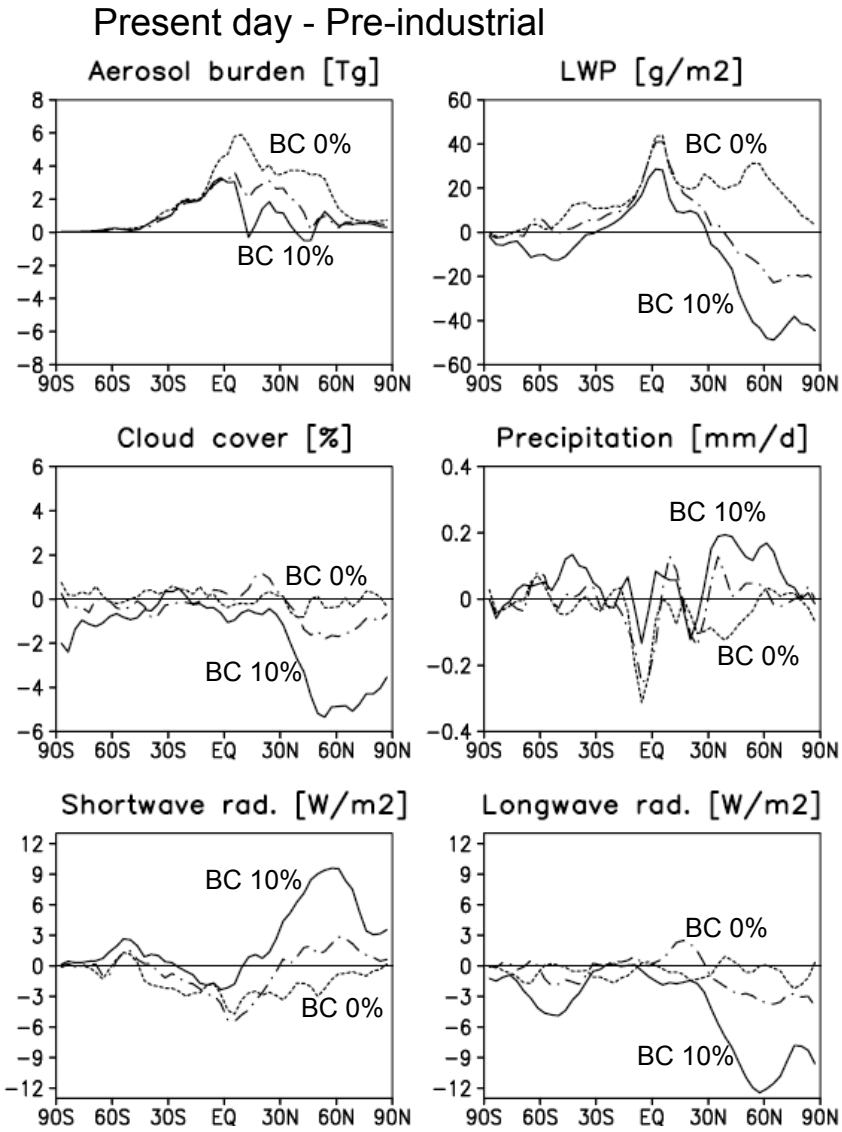
Aerosol Column Mass



Kinne et al., An AeroCom initial assessment. *Atmos. Chem. & Phys.*, 2006.

Why Study Ice Nucleation in the Arctic?

- Anthropogenic changes in ice nucleation may influence aerosol burden and climate.
- The treatment of ice nucleation in models affects the aerosol scavenging efficiency.
- A variety of ice nucleation mechanisms are involved.
- A counterflow virtual impactor can be used to isolate ice nuclei from the cloud particles and then determine size and composition.
- ASP could provide the first Arctic measurements of ice nuclei size and composition.



Lohmann, A glaciation indirect aerosol effect caused by soot aerosols. GRL 2002.

Key ARM Aircraft Measurements

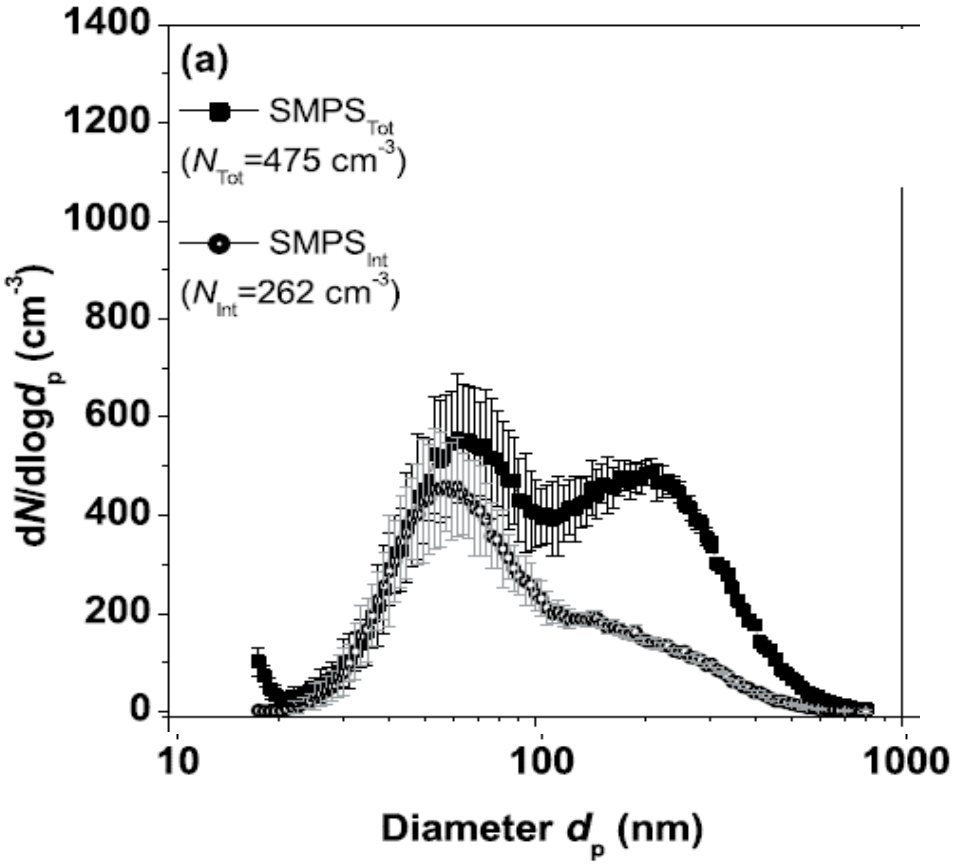
Instrument	Measurements
TSI 3025	total particle concentration (> 3 nm)
DMA	aerosol size distribution (0.01-0.75 mm)
PCASP	aerosol size distribution (0.1-3 mm)
TDMA	Size-resolved aerosol hygroscopicity (0.015 - 0.6 mm)
DMT CCN counter	CCN concentration (one S)
CFDC	IN concentration
PSAP	optical absorption
Gust probe	updraft velocity
DMT CAPS	temperature, LWC, cloud particle size dist (0.5-1500 mm)
DMT CSI	total condensed water concentration
SPEC CPI	cloud particle image 15-2500 mm
CIN	cloud extinction coefficient, asymmetry parameter

ASP Instruments and Measurements

Instrument	Measurement
Counterflow Virtual Impactor	Cloud-borne aerosol
Scanning Mobility Particle Sizer	Aerosol size distribution 3-1000 nm
PCASP	Aerosol size distribution 0.1-3 μm
TSI 3010, 3025A	Total aerosol number
DRI CCN Spectrometer	CCN spectrum
Particle-in-Liquid System	Particle ionic composition
Aerosol Mass Spectrometer	Size-resolved composition
Time-Resolved Aerosol Collector / CCSEM/EDX	Single particle chemical composition and mixing state
DRI Photoacoustic	Aerosol absorption

Aerosol Scavenging

- Two conditions for wet scavenging of aerosol:
  - Attachment to hydrometeor
  - Precipitation of hydrometeor
- Evaluate first condition by comparing simulated and observed partitioning of aerosol between interstitial and cloud-borne
- Evaluate second by comparing simulated and observed hydrometeor size distribution and precipitation rate



Henning, Bojinski, Diehl, Ghan, Nyeki, Weingartner, Wurzler,and Baltensperger: Aerosol partitioning in natural mixed-phase clouds. GRL 2004.

Deep Convective Clouds and Chemistry

June-July 2009 Colorado - Oklahoma

Steven Ghan (PNNL)

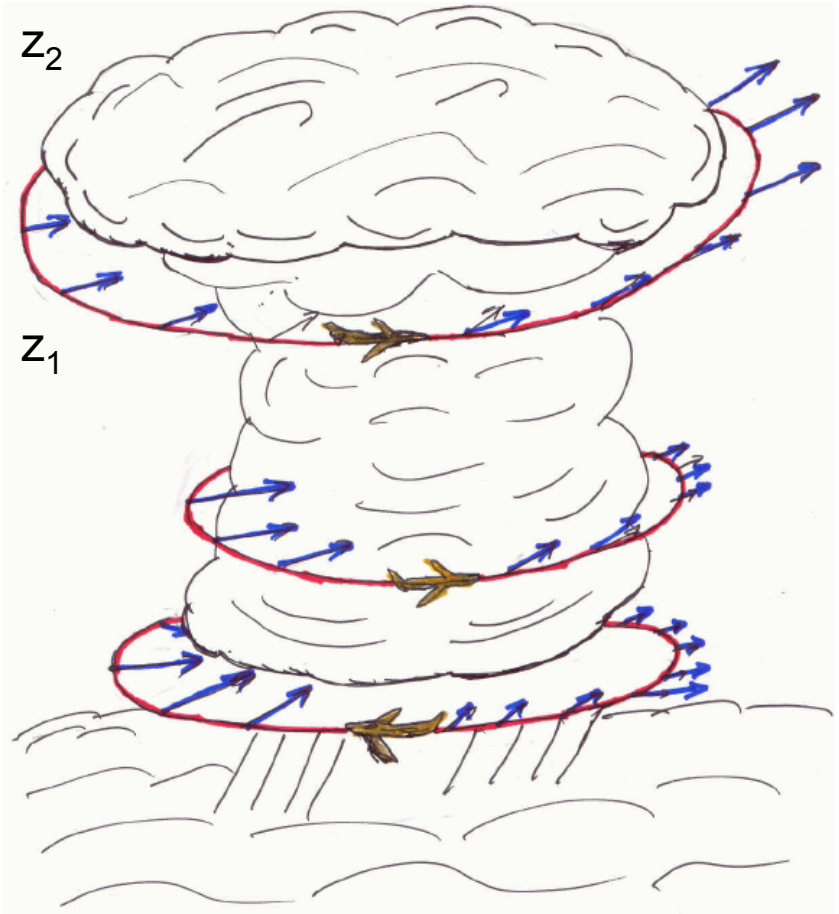
Mary Barth, Bill Brune, Chris Cantrell (NCAR)

Steve Rutledge (CSU)

- Deep convection plays important roles in vertical transport, aqueous-phase sulfate production, nucleation, and scavenging of trace chemicals and particulate matter.
- The representation of this influence in global climate models is highly uncertain.
- Several ASP projects address this challenge.
- DOE does not have an aircraft that can sample detrainment of trace species from deep convection.
- DC3 would provide upper tropospheric measurements that would complement DOE measurements in the lower troposphere.

Pollutant Mass Closure (Don Lenschow)

- Circles around cloud at 3 km altitude intervals
- Flux of q into cloud: $F_q(z) = \frac{1}{A}\oint_C v_\perp q dl$
- Entrainment below z_1: $E_q = \int_0^{z_1} \rho F_q dz$
- Detrainment above z_1: $D_q(z) = -\int_{z_1}^{z_2} \rho F_q dz'$
- Scavenging ratio $S_q = \frac{E_q - D_q}{E_q}$
  - S=0 for dry air
  - S~1 for water, soluble gases and large soluble particles
  - S<<1 for insoluble gases



Key Platforms

- DC3 would provide
  - NSF/NCAR G-V to sample the convective *outflow* of aerosol and trace gases in the upper troposphere
  - either the NASA DC-8 or the NSF/NCAR C-130 to sample the *inflow* of aerosol and trace gases in the middle troposphere
- ASP would provide the G-1 to sample the *inflow* of aerosol and trace gases in the lower troposphere

Key Measurements

Measurement	DC-8	G-V	G-1
O_3, CO, HNO_3, SO_2	1	1	1
NO, NO_y, NO_2	1	1	1
H_2O vapor	1	1	1
Peroxides	1	1	1
CVI		2	
Aerosol size distribution	1	2	1
CCN	1	2	1
Size-resolved aerosol composition (AMS, PILS)	1	2	1
Time-Resolved Aerosol Collector		2	1
Winds, T, p, location	1	1	1

1: essential. 2. desirable